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Inside: Engaging Latinx Audiences Through the Cultural Roots of STEM

Plus: Public Library Response to COVID Part 2, Transforming Undergraduate Education, and MORE!

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Engaging Latinx Audiences Through the Cultural Roots of STEM

By Isabel Hawkins and María Ávila Vera

AN UNLIKELY PARTNERSHIP

The story of how Doña María[1] and Isabel—the co-authors of this article—became colleagues and friends is rooted on our shared love of astronomy. This fifteen-year collaboration between a Maya grandmother from the Yucatan, Mexico and an astrophysicist from Córdoba, Argentina would lead to many adventures and a shared journey of mutual learning in the context of Science, Technology, Engineering, and Mathematics (STEM). One of our first collaborative efforts was the development of the *U Úchbenil le K'ino' | Tradiciones del Sol | Traditions of the Sun* trilingual book in Yucatec Mayan, Spanish, and English that juxtaposed Maya solar astronomy with NASA heliophysics (Hawkins and Thieman 2006). The partnership has been mutually beneficial, instilling a greater sense of pride in her ancestral legacy of science (in the case of Doña María) and increasing her ability to resist narrow conceptions of what science is, what qualifies as a scientist, and why and how we engage in science (in the case of Isabel).

Eighty-two years ago, Doña María was born in the village of Xul, where Yucatec Mayan is the primary language spoken by the community. Traditional farming of native corn, beans, squash, tomatoes, chiles, and other native foods is an important daily activity in the town. To plan the cycles of traditional agriculture, residents of Xul and neighboring communities have been observing the Sun, Moon, and Maya constellations for countless generations. Doña María enjoys sharing memories of her childhood and how observational astronomy was part of daily living in her village. She tells how her uncle taught her to measure the passage of time by tracking shadows and how they observed the sky to know when to cultivate certain foods. The time for planting corn was bracketed between the instant when "the face of the Sun was reflected at the bottom of the well," and when "*tsab (the rattle of the snake)*" appeared above the horizon before dawn. In western astronomical language, what Doña María observed is the zenith passage of the Sun in mid-May, when our star travels through the point directly overhead (a phenomenon that only occurs within the tropics), and the heliacal rise of the Pleiades star cluster in mid-June.

Sixty-two years ago, Isabel was born in Córdoba, Argentina, where she grew up spending summers in a ranch with no running water and no electricity. This remote location, called "*El Cercado*" was and still is one of the best places to enjoy the stars and dark skies, since there is little artificial light contamination. As a child, Isabel stayed up late at night staring at the sky to see falling stars, and every morning would entice her cousins to go find the star that had surely lodged itself in the distant landscape. Her favorite constellations were "*el puñal (the sword)*" and "*las siete cabritas (the seven baby goats)*." In western astronomical language, what Isabel observed were meteor showers, the constellation of Orion, and the Pleiades star cluster (both seen upside-down from the perspective of the Southern Hemisphere).

Figure 1: Doña María Ávila Vera (left) and Isabel Hawkins (right).

THE CULTURAL ROOTS OF STEM

Our work focuses on broadening the participation of Latinx communities in informal science learning experiences by helping to make visible the cultural roots of STEM—the worldviews and systems of knowledge acquired through sustained relationships of a community with their environment over many generations. We do this by featuring examples of popular traditions, e.g., Day of the Dead (Hawkins 2021), together with explicit science connections that showcase the essence of Latinx cultural roots and draw from the evidence, past and present, of a thriving people that developed STEM knowledge and practice in their native lands before the arrival of Europeans. Such examples can help uncover the role of dominant and non-dominant

cultures, subjectivity, and perspective in making sense of the world, drawing attention to the idea that people interpret reality through a particular cultural lens (Medin and Bang 2014). It is important to state that a focus on equity and increasing the participation of Latinx people in STEM are, in and of themselves, insufficient and that we must embrace the central role that new and creative ideas play in the scientific endeavor, challenging the mainstream view of science as existing outside of culture.

Throughout history, humans all over the world have developed different views and understanding of nature that are culturally specific. Culture encompasses traditional knowledge systems that indigenous people use to understand and interpret their biophysical environment (Cajete 1999). These systems of knowledge constitute an integral part of the cultural identity and social integrity of many indigenous populations (Mazzocchi 2006). "Los mejunjes y ungüentos de la Abuelita"—Grandma's concoctions and ointments used as home remedies—embody a wealth of knowledge and wisdom experienced from nature gained over generations of direct observation and mainly transmitted through the oral tradition. To gain greater clarity from the challenges and opportunities of considering diverse ways of knowing, it is helpful to juxtapose our views of science from western and indigenous perspectives.

Western Science, from a Eurocentric perspective, is just science—acultural, unbiased, and value neutral. Scientific research is made objective by striving to eliminate potential biases, emotions, and spirituality. As a social and collaborative endeavor, western science has well-structured norms and utilizes fundamental processes such as empiricism, where knowledge is derived from experiments, and scientific inquiry, where prior knowledge, critical thinking, and scientific reasoning interplay to develop new scientific understandings. The processes and skills of western science include observing, inferring, classifying, predicting, measuring, questioning, and interpreting and analyzing data. The scientific endeavor encompasses basic science for the continued exploration of myriad scientific disciplines and the use of advanced technologies and their application to industry, pharmaceuticals, medicine, information technology and computing.

Indigenous Science, from an indigenous perspective, is a way of living in balance and reciprocity with the universe. In indigenous worldviews, there are multiple ways of knowing, including science, that are culturally dependent. Indigenous science is relational, interdependent, and place based. While indigenous experts gain knowledge through empirical observations and interactions with nature, they view themselves as part of nature, not separate from it. Indigenous knowledge is holistic and does not separate the empirical from the sacred. Indigenous science has been evolving for thousands of years and relies on knowledge applied over many generations. Examples of indigenous science include the domestication of thousands of native foods, sustainable agriculture, the use of medicinal plants for community health, and the development of technologies using regional materials that are attuned to the local environment.

Despite differences, the diverse ways of knowing exemplified by western and indigenous approaches to STEM can be complementary and mutually reinforcing. In a pluralistic society, pedagogical practice can go beyond cultural relevance towards cultural valuing (Ladson-Billings 1995). Research on "Funds of Knowledge" (Moll & Gonzalez 1994), "Third Space" (Gutierrez 1998), "Culturally Sustaining Pedagogies" (Paris 2012), a "Science of Place" (Valdez and Hawkins 2021), and "Nature-Culture Constructs" (Bang and Marin 2015) are foundational to effective science teaching and learning and encourage us to move from deficit approaches to methodologies that acknowledge the legacy of STEM in indigenous and Latinx communities.

MÉRIDA DOMINGO AND THE PLANETARIUM

On a hot and humid Sunday when Doña María and Isabel were visiting Mérida, the capital of the State of Yucatán, Mexico, the Plaza Grande was packed with revelers who came to enjoy the beloved "*Mérida Domingo*" weekly festivities. Multi-generational local Maya families, mestizos[2], and tourists enjoyed social dances and staged musical performances, book fairs, traditional foods, ice cream and balloon vendors, and stalls selling arts, crafts, and our favorite embroidered *huipiles*[3]. The cultural importance and complexity of festivities in Mexican culture has been famously discussed by the Nobel laureate and literary giant Octavio Paz (Paz 1985).

The city's Planetarium sits on a corner of the main square. Isabel asked Doña María if she had been to the Planetarium, and the reply was "*Oh, no, we don't go to those places.*" As a matter of fact, Doña María did not know it was a planetarium, or even what a planetarium was. The reason why "those places" were not appealing to her and her family, was because the building and setting lacked a welcoming "vibe." There was no festive or fun atmosphere, and it was unclear what activities went on inside the sober-looking space. This and several future shared experiences encouraged us to collaborate with integrity, each of us operating within our area of expertise and cultural backgrounds, to co-create programs and activities that would be culturally and scientifically welcoming to a broader spectrum of Latinx audiences.

Collaborations between traditional knowledge holders and

scientists thrive through a mutually reinforcing exchange of lived experience and formal training (Maryboy, Begay, and Peticolas 2012). Growth takes place at the intersection and confluence of traditional knowledge and western science. For the mainstream scientist, it takes experience and a multidisciplinary approach to identify the STEM components within traditional knowledge. For the traditional knowledge holder, becoming aware of the STEM content or practice within a cultural tradition can elicit a sense of pride in the fact that the community has a legacy of science that is culturally specific. Sustained collaboration and depth of relationship to develop mutual trust are important.

Educational research in the U.S. has shown that learning experiences in out-of-school, free choice environments can positively influence performance and attitudes toward science and science careers in school children (NRC 2009). However, the experience during "*Mérida Domingo*" showed that creating informal learning experiences that are accessible to a culturally and linguistically diverse public can be challenging (Acevedo and Madara 2015). In the case of Latinx audiences, barriers of participation go beyond the cost of admission, language, or access to transportation. Creating a welcoming environment in museums and offering STEM content that acknowledges non-European norms are deeper and more difficult issues to address. Museum experiences are often out of step with the leisure values of Latino audiences and fall short of reinforcing cultural identity and a culturally grounded legacy of science (García-Luis, Hawkins, Blanco, and Oates 2017; Garibay, Lannes, and González 2017; Scansion 2017).

We embraced the opportunity to create programs for Latinx audiences in Latin America and the U.S. that could bring the attributes of a "*Mérida Domingo*" to life within informal science learning settings. The challenge for museums, science centers, and planetariums is to build institutional capacity to collaborate with traditional knowledge holders as well as mainstream Latinx scientists and, importantly, to honor the cultural roots of STEM.

COMUNALIDAD

In 2013, we were invited by Zapotec and Mixtec colleagues to Oaxaca, Mexico, to participate in the "*Guelaguetza*" cultural event of regional traditional music, dress, dances, and food. The tangible festivities are just the tip of the iceberg, since the deeper meaning of *Guelaguetza* is the celebration of mutual interdependence among members of the community. *Guelaguetza*, a Zapotec word, means "to gift, share, or offer a service." The authentic experiences facilitated by our hosts helped us understand that the underpinning of *Guelaguetza* rests on the concept of "*Comunalidad*," espoused by Oaxacan anthropologists Rendón Monzón (2003) and Martínez Luna (2009). *Comunalidad* is a dynamic process, a dialogue between the lived experience of original peoples in Mesoamerica and indigenous scholars naming and describing this worldview and perspective. The theory centers around four aspects of active participation in communal life: relationship and permanence in a territory; reciprocity and communal work for the benefit of all; communal authority and governance via the popular assembly; and communal celebration, or feast days. *Comunalidad* reflects a people's culture, and culture reflects the relationship between humans and the local biodiversity. *Comunalidad* has four components (Figure 2).

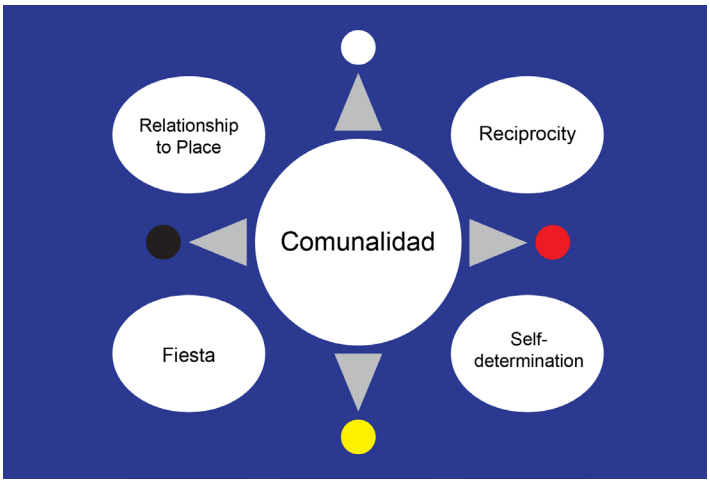

Figure 2: The components of Comunalidad. Illustration by Mary Ellen Hawkins.

Relationship to Place—refers to a profound understanding of the processes of nature, gained over many generations of living in relationship with a territory or locale.

Reciprocity—refers to acts of mutual help for the benefit of neighbors and the community, as well as reciprocity with the Earth through offerings and ceremony.

Self-determination—refers to making decisions by and for the benefit of the community. Community comes first, and decisions seek to nurture the whole, beyond the needs of individuals.

Fiesta—The *fiesta* (feast) is a form of cyclical closure and renewal. The extravagant and abundant display of riches during popular feasts affirms the wellbeing of the collective—the health of the people.

As a tool of social justice, *Comunalidad* is a form of resistance to colonial assimilation; it acknowledges the people, their energy, their knowledge, and innovation. To quote Martínez-Luna (2009): "We are communality, not individuality; we are communal territory, not private property; we are generosity, not competition; we engage in exchange,

not commerce. We are diverse and interdependent." The cultural roots of STEM live within the framework of *Comunalidad.*

ENGAGING LATINX AUDIENCES IN INFORMAL SCIENCE LEARNING ENVIRONMENTS

In this section, we provide examples of museum programming at the Exploratorium in San Francisco that honor the cultural roots of STEM within a framework of *Comunalidad*. All the examples incorporate the components of *Comunalidad* through feasting, reciprocity, and collaboration with representatives of the Latinx communities. The activities share knowledge and expertise that are home grown in Latin America and serve as a source of pride to Latinx audiences, providing opportunities to learn about scientific accomplishments that are connected to identity, reciprocity, celebration, and a deep relationship to place. As museum practitioners, we are continually seeking similar examples to enhance our ability to develop culturally sustaining informal science learning experiences for our audiences. Our approach resides at the intersection between culture and science and uses both non-Eurocentric examples, past and present, of Latin American STEM legacy and expertise, as well as role models of Latinx successes in mainstream STEM careers in the U.S.

"Día de las Madres | Mother's Day" Public Program and the Science of Corn

Mother's Day is a popular holiday worldwide. In several Latin American countries, including Mexico, Guatemala, and Panama, Mother's Day is a national holiday. Celebrating "*las mamás Latinas*" includes music concerts and serenades, dance performances, traditional foods, and flowers. Since 2014, the Exploratorium has produced a yearly public program on Mother's Day that attracts up to 7,000 museum visitors, most of them intergenerational Latinx families. The program is one of the museum's Community Days, with a "pay as you wish" admissions policy. Programming features Mariachi concerts, "*folklórico*" dances from local troupes, and a hands-on "*flores de papel*" activity, where a renowned Mexican artist leads families in making bouquets of paper flowers to gift their Moms. To highlight the cultural roots of STEM, we present the science of corn and companion planting, and facilitate a tortilla making (and eating) activity for the public. Most countries in Latin America consider maize their most important native food. The ancestors of contemporary Mesoamericans developed and implemented an innovative chemical process called nixtamalization to convert maize into a complete protein by the addition of an alkali element during cooking. The resulting chemical reaction releases niacin, thus allowing maize to serve as a nutritionally complete staple food and prevent the development of a deadly disease, pellagra. Doña María showed how she cooks dried corn seeds with "cal" (slacked lime) to peel off the hull, allowing the dough to form and releasing niacin. During the presentation, we acknowledge the local diversity of our Latinx audiences by asking visitors to share about their favorite corn-based foods (i.e., a Venezuelan *arepa* is different from a Mexican *tamal*, a Salvadoran *pupusa*, or an Argentinian *humita*; yet all these foods rely on corn cooked with an alkali component). The tortilla making activity contributes to a greater understanding of the relationship between people and their environment over thousands of years.

Figure 3: Doña María Ávila Vera engages families in the science of corn through a tortilla-making activity at a Mother's Day event at the Exploratorium.

Pigmentos Naturales | Natural Dyes and Explainer Training

The cultivation and harvesting of natural pigments in Oaxaca, Mexico relies on the symbiotic relationship between insects, plants, mollusks, and humans over thousands of years. The cochineal insect that grows on the nopal plant thrives in the dry valleys of Teotitlán, both in wild

Figure 4: Natural pigments from Oaxaca, including insects, plants, and minerals used during a workshop on the chemistry of dyes.

Figure 5: Modeling traditional clothing at an Explainer training workshop led by Exploratorium volunteer Diana Hernández from Oaxaca, Mexico.

and domesticated forms. By mixing the dried and ground cochineal with several mordants, such as lime juice and ash, Zapotec weavers can produce more than 300 hues in the carmine-orange-yellow palette. Blues are obtained from "*añil*," a local plant used to make indigo. Purples are obtained by sustainably milking the "*plicopurpura pansa*" sea snail, whose ink turns purple when it mixes with oxygen. The Exploratorium hosted a Oaxacan volunteer who teamed up with one of our scientists to present several training workshops for our explainers and the public, who learned about the chemistry of valent and covalent bonds and the process to make natural dyes using sustainable environmental practices in Oaxaca. Interactions involving Doña María, Isabel, Exploratorium scientists and Explainers, and the Oaxacan expert offered a rich cultural exchange and discussion about traditional clothing in Mesoamerica, especially *huipiles*.

Día de la Ingeniería | Latinx Engineering Day and a Woven Suspension Bridge

Q'eswachaka (meaning "grass bridge" in the Quechua language) is the name of a woven bridge in Peru—the only remaining suspension bridge of Inka design. Every year in June, the 500-year-old tradition of renewing the grass bridge is maintained by members of four Quechua communities led by Don Victoriano Arizapana Huallhua, the bridge's architect and engineer. We visited Peru to interview Don Victoriano and shared knowledge cross-culturally (Native Knowledge 360°-NMAI 2016a,b).

Figure 6: Don Victoriano Arizapana Huallhua from Huinchiri, Peru, crossing his community's Q'eswachaka suspension bridge.

Don Victoriano engages the participation of one thousand people from neighboring communities who harvest a local grass, twisting it together to form the strong cables used to support the bridge. More than 600 years ago, Don Victoriano's Inka ancestors designed a suspension bridge that operates primarily on tension—the most appropriate technology to solve the problem presented by steep canyons and gorges. The knowledge was passed down through the generations and the bridge has been continually renewed using the same techniques ever since. The Q'eswachaka bridge can withstand a load of 4000 pounds, equivalent to a small car or 12 loaded llamas. Engineering concepts such as compression and tensile strength emerge from this unique example and are demonstrated as part of Latinx Engineering Day via a participatory bridge-making activity for families. Engineering career paths, personal stories, and challenges and opportunities are discussed by Latinx engineers representing the Society of Hispanic Professional Engineers, who spend a few hours interacting with the visiting public during panel presentations.

CONCLUSIONS

When it comes to engaging local Latinx audiences in in-

Figure 7: Doña María and Don Victoriano exchanging knowledge in Huinchiri, Peru.

formal science learning experiences, museums and other institutions typically find it more comfortable to share the cultural roots of arts and crafts, food, music, and dance in their programming; however, museums are not as comfortable highlighting the cultural roots of STEM. In thinking about why, several reasons emerge, including challenges in establishing collaborations, building capacity in the museum staff to work cross-culturally, the lack of travel funding to learn from place, and the fact that, frankly, it is hard! Developing the capacity to collaborate with integrity in knowledge and practice requires cross-cultural engagement sustained over many years. Honoring and embodying the cultural roots of STEM is not a contact sport, it is lifelong endeavor. From a social justice perspective, we

Figure 8: Isabel Hawkins facilitates a hands-on activity on "tension and compression" for families at the Exploratorium during a Latinx Engineering Day public program.

also believe that the hesitancy in broadening worldviews of science by acknowledging the cultural nature of science itself, has to do with the unwillingness of the dominant culture to share the power, the prestige, and the resources associated with the STEM enterprise with non-dominant audiences.

Museums can invite traditional knowledge holders from the Latinx community who understand STEM through their lived experience. The expertise of Doña María Ávila Vera and Dr. Isabel Hawkins lie on a continuum that rests on the long-standing legacy of science in Latin America: a home-grown STEM that continues to thrive despite hundreds of years of colonial destruction, discrimination, formal education in urban settings, and attempts at assimilation. Youth and elders in Latin American communities are taking ownership of their legacy of STEM to revitalize their ancestral knowledge, with recent examples familiar to the authors led by Guatemalan cultural astronomers (Poz Salanic and Barreno 2021; Poz Salanic 2021; Barrientos, et.al., 2021) and traditional healers (Raxnaq'il Nuk'aslemal 2016).

In the U.S. other efforts include the work of the Oregon Museum of Science and Industry and their work with local indigenous and Latinx communities to showcase culturally rooted astronomy, technology, and biomimicry through exhibits, programs, and other installations, e.g., the Roots of Wisdom exhibit (OMSI 2015). The Smithsonian National Museum of the American Indian is embedding culturally rich STEM in their exhibits, websites, educational online lessons for K-12 educators, and public programs (Native Knowledge 360°-NMAI 2012 and 2019). The Smithsonian Latino Center's Young Ambassadors Program has been actively mentoring Latinx youth, sharing content and expertise that also highlight the cultural roots of STEM. Additional efforts are needed, and we hope that this article, which has focused on sharing our personal and professional story of collaboration, will encourage colleagues in our field of informal science education to continue to produce and share the impact of programs that honor the cultural roots of STEM, through research and lived experience.

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ENDNOTES

[1]"Doña" is not a name, but an honorific bestowed to elders in Latin America and other regions where the Spanish language is prevalent.

[2]Mestizos are people of mixed European and American

Indian ancestry.

[3]From the Nahuatl language, a huīpīlli [wiːˈpiːlːi] is the traditional blouse or dress worn by indigenous women from Mesoamerica. In the Yucatan, the word is pronounced "ipil."

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